Potential of Remote Sensing in the Far-Infrared Region

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Motivation

The far-infrared spectral region covering wavelengths between 15 μm (667 cm^{-1}) and up to about 100 μm (100 cm^{-1}) has been studied by only a small number of instruments, and never from Earth satellite. Among others, the reasons for this are:

- decreasing intensity of the radiation towards longer wavelengths and,
- high requirements on the instruments concerning sensitivity and cooling of the detectors.

However, roughly 50% of the Earth's terrestrial radiation budget is determined by the far-infrared atmospheric emission to space. A good knowledge of the radiation processes in this spectral region is of high interest for observations and understanding of heating and cooling rates, and global energy balance.

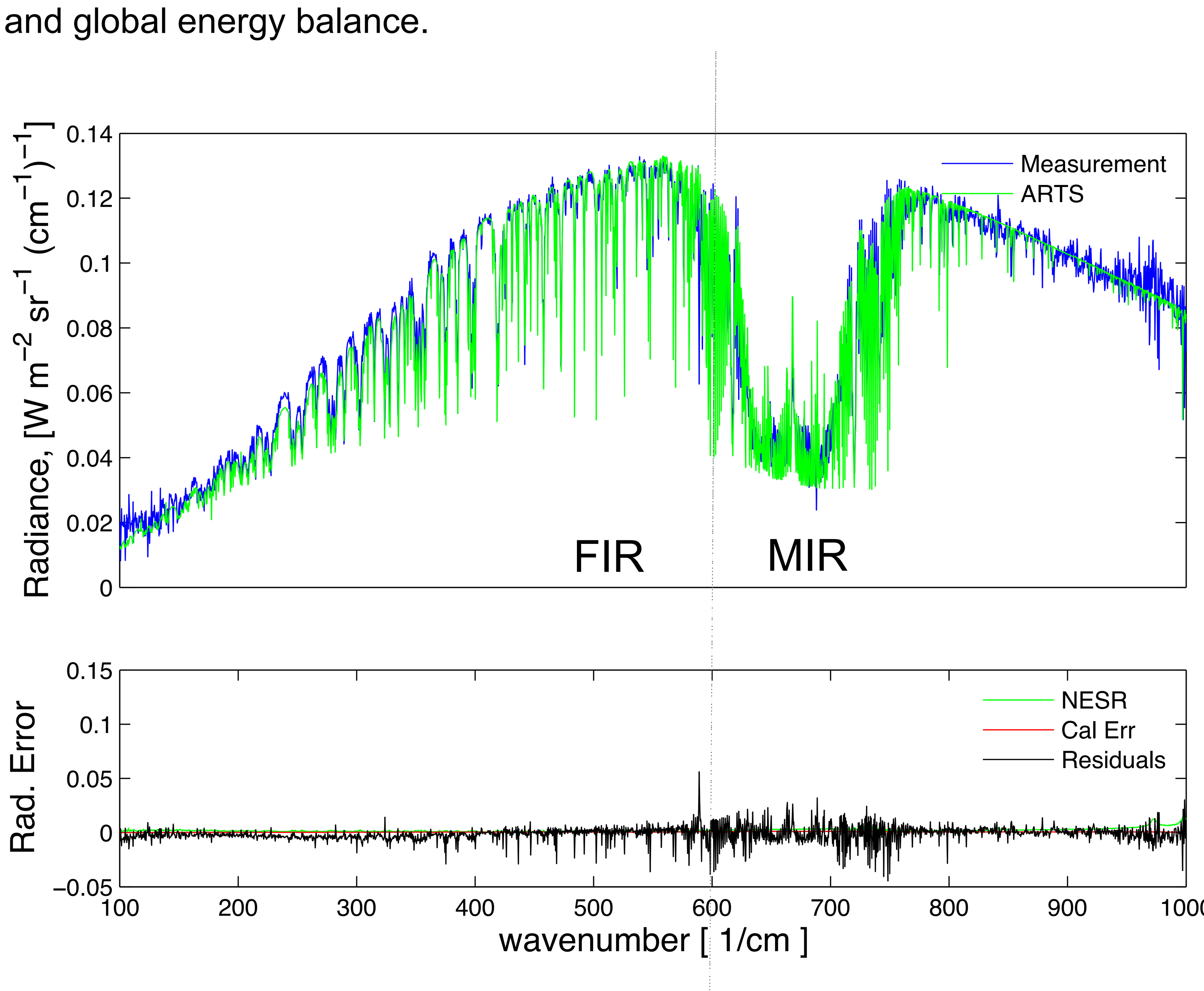

Figure 1: Measured FIR spectrum from a balloon borne nadir looking instrument and spectrum modeled using ARTS, based on modeled atmospheric states (CTM-EMAC) in Teresina, Brasil, June 30, 2005. The lower panel shows instrumental NESR and difference between measured and modeled spectrum.

Balloon Borne FTIR: REFIR-PAD :

- Mach-Zehnder non polarizing Fourier transform spectrometer
- Spectral range: 100-1400 cm^{-1} (100 – 7.1 μm)
- Spectral resolution: 0.4 cm -1 (unapodized)
- Acquisition time, 80 s/scan

Cooling rates:

Cooling rate is a measure of the rate of temperature change of an atmospheric volume due to loss of energy by emission of radiation [2].

$$\left.\frac{-dT(z)}{dt}\right|_{\nu} = \dot{Q} = \frac{1}{\rho(z)c_p}\frac{dF(z)_{\nu}}{dz}$$

where, T, t, ρ, c_p, F and z are temperature, time, air density, heat capacity (for pressure work), net radiative flux and altitude, respectively, at a given wabvenumber ν

Cooling rate and radiative flux profiles are determined by the atmospheric state such as profiles of temperature and trace species relevant .

References:

Liuzzi, Giuliano, et al. "Validation of H 2 O continuum absorption models in the wave number range 180–600 cm− 1 with atmospheric emitted spectral radiance measured at the Antarctica Dome-C site." *Optics express* 22.14 (2014): 16784-16801.

Harries, J., et al. "The far-infrared Earth." *Reviews of Geophysics* 46.4 (2008).

Jacobians

The sensitivity of the spectrum to changes in atmospheric parameters can be displayed in terms of so-called Jacobians (dR/dx). In Fig. 2, Jacobians concerning different trace species and atomspheric temperature are displayed.

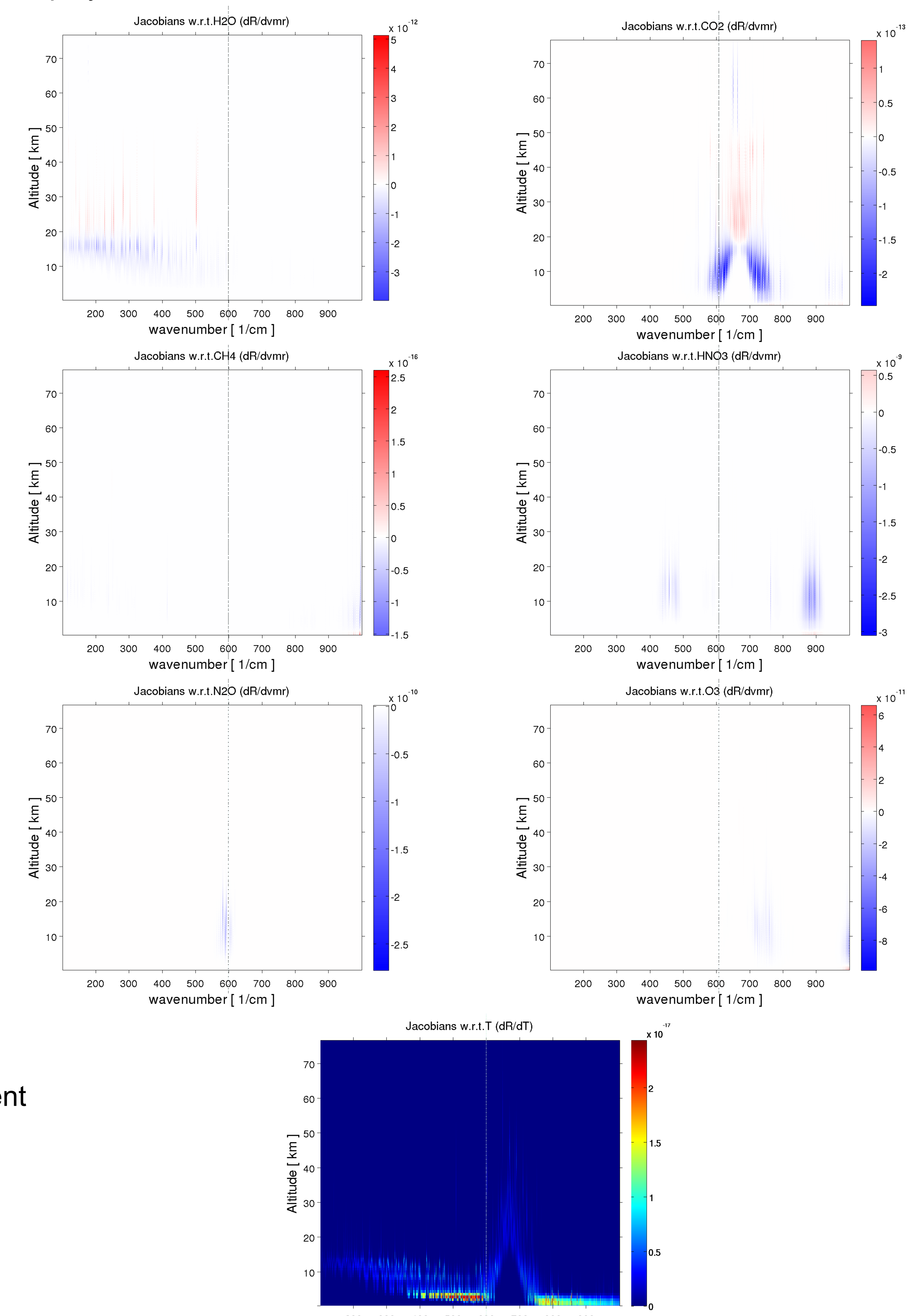

Figure2: Jacobians of the modelled spectrum with respect to H_2O, CO_2, CH_4, HNO_3, N_2O, and O_3 in terms of dR/dvmr(1). The jacobians for temperature are in terms of dR/dT.

Conclusions:

- The simulation of balloon borne measurements in the FIR agree very well with actual measurements, using modeled data for the measurement date.
- The spectra in this region are dominated by all major greenhouse species.
- The FIR region has significant contribution to atmospheric cooling rate
- Knowledge of the FIR is important to fill a gap in the understanding of the outgoing long wave radiation.
- Upcoming satellite borne spectrometers in the FIR, such as the proposed instrument FIRST (Far-Infrared Spectroscopy of the Troposphere) on the NASA Climate Absolute Radiance and Refractivity Observatory (CLARREO) or the FORUM proposed for ESA's Earth explorer call, will help to re-assess the global radiation budget and understand the role of the FIR region.
- Unknown spectral transitions in the FIR can be explored with future instruments.
- This work will lead to approaches to retrieve atmospheric parameters and atmospheric cooling rates in the FIR range.

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